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Cognitive Competence of Prospective Elementary Teachers on Realistic Mathematic Education through Cooperative Learning

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Abstract: - Having cognitive competence in mastering learning theory and designing learning is one of the important competencies for prospective teachers to have. The description of prospective teacher competence is important for lectures to follow up. One approach to learning in mathematics is Realistic Mathematic Education (RME). RME is a student-centered approach to learning mathematics adopted from the Netherlands and holds to the principle that mathematics is a human activity. This learning approach has been implemented massively in the last few decades in Indonesia and has had a positive impact so this approach is important to teach. However, there are still many prospective elementary teachers who do not know and understand what and how to implement RME itself. Because of the importance of the cognitive competence that prospective elementary teachers must have regarding this RME approach, further research is needed on this matter. The aim of this study is to describe how the cognitive abilities of prospective elementary teachers on RME approach with the application of cooperative learning. The method used in this study was descriptive qualitative with observation and survey data collection techniques which were analyzed using cognitive levels according to PISA and Anderson on 50 prospective elementary teachers in Yogyakarta State University or in Bahasa Universitas Negeri Yogyakarta (UNY) 4th semester students. The results of this study were that most students had a fairly good theoretical understanding of RME. Although to apply it in learning mathematics requires more training, especially in designing contextual problems and how to evaluate them with various other approaches in learning mathematics.

Keywords: Cognitive competence, cooperative learning, RME

I. INTRODUCTION

Graduate competency standards [8] (Permendikbud, 2020) concerning National Higher Education Standards, namely graduate qualifications that include attitudes (affective), knowledge (cognitive) and skills (psychomotor). The ability of knowledge (cognitive) referred to is graduates who have systematic mastery of concepts, theories, methods, and/or philosophies of certain fields of mathematic obtained in the learning process. According to Bloom's level of cognitive ability [2] (revised by Anderson & Krathwohl, 2001), namely: remember, understand, apply, analyse, evaluate and create. While the competency levels in PISA, OECD [11] (Sahar et al, 2019), namely: (1) Reproduction: is the ability to describe technically and technically the background of phenomena, (2) Connection: utilizes knowledge and understanding of inquiry to identify questions, can explaining the scientific process of the products used, proposing innovative steps in overcoming problems, (3) Reflection: interpreting and evaluating data and scientific evidence, and making conclusions that can be accounted for. Prospective elementary teachers are expected to have good cognitive abilities in terms of mastery of learning theories and principles in order to design optimal learning.

Realistic Mathematics Education (RME) is a mathematics learning approach adopted from the Netherlands, in Indonesia known as PMRI (*Pendidikan Matematika Realistik Indonesia*) which was developed from the Freudenthal Institute. Hans Freudenthal in 1971, stated mathematics as a human activity. One of the principles of implementing RME is the use of context as a starting point in starting learning. RME itself in Indonesia has been applied massively in mathematics learning, starting from elementary school to university levels as a form of teaching, research and community service. Learning uses a student-centred approach and learning materials use local cultural contexts that students experience in real terms in everyday life [10] (Ratu Ilma Indah Putri, 2015). The RME approach has had many positive impacts on the world of education in Indonesia, especially at the elementary school level. It is because the characteristic of elementary student in Indonesia based on the levelling of cognitive

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category by Jean Piaget, they are in the concrete operation stages (7 to 11 years old). In this stage, children develop the capacity to think systematically, but when they can refer to concrete objects and activities [5] (Crain, W, 2014). This stage also suitable with one of the characteristics of RME that is the use of context itself. RME has been proven to be able to increase understanding of mathematical concepts to students' problem-solving abilities [4] (Agustina, Ninda, 2020). This is because in the application of RME, students play an active role to build their own knowledge so that it affects students' increased interest in learning and has an impact on increasing understanding of the material. For prospective elementary teachers to get a theoretical and practical understanding of the RME approach is obtained through Mathematics Education courses in Elementary Schools. At Yogyakarta State University, the curriculum is structured for semester 4 students so they can take these courses and deepen the theories of learning mathematics, especially an introduction to the RME approach.

One learning model that can be applied to teach RME is cooperative learning. Cooperative learning has a good impact on increasing the cognitive competence of prospective teachers when implemented in learning at the university level [7] (Karacop & Diken, 2017). Cooperative learning is a cognitive practice that equips students with cognitive, affective and psychomotor achievements when they have the opportunity to interact with others [6] (Devi, Anit Pranita, 2015). It would be better if prospective elementary teachers, in designing mathematics learning, had in-depth knowledge of mathematics learning theory, especially RME. In terms of its implications for lecture activities and based on the results of researchers' observations, the class capacity is quite large with 50 students in it, posing its own challenges to introduce the RME approach. Having an overview/description regarding the cognitive competence of prospective elementary teachers regarding the RME approach is important for lecturers to be able to follow up on lectures in order to produce professional prospective teacher graduates [15] (Tarusu, 2018). Therefore, the researchers designed this study to describe the cognitive competence of prospective elementary teachers on RME approach by applying the cooperative learning model.

II. Research Method

The method used in this research is descriptive qualitative, which was conducted on fourth semester prospective elementary teachers consisting of 50 students. Before the learning process starts, researchers observe the student whether they have already known about RME or not. Lectures were held to introduce RME using the cooperative learning model for three meetings. The first meeting introduced RME learning theory, principles and characteristics. Then the next meeting was simulation and design of RME-based learning properties. In the last meeting students were asked to answer survey questions to see cognitive achievements regarding RME. The following questions are given to students:

1. What do you know about RME? Explain.

2. How is RME applied? How is this approach different from other approaches you have studied? Explain.

3. Design a contextual problem that can be applied to RME, and explain what mathematical concepts will be taught using this context. Then evaluate this approach to problems designed by considering different approaches.

The questions used are references that have been translated from previous research questions [18] (Yilmaz, 2020) on prospective teachers in Turkey. The timeframe for answering questions is 1 hour. The results of the survey questions will be grouped and analysed based on the level of student ability/understanding of RME.

III. Result and Discussion

The main objective of this study is to describe the cognitive competence of prospective elementary teachers at RME with the application of cooperative learning. Researchers conducted an observation to find out whether the term RME itself had been heard or known further by students. From the results of the initial survey, as many as 78% of 50 students did not know RME at all. So that three learning meetings were carried out to introduce RME to students by applying the cooperative learning model. At the end of the meeting, another survey was conducted to see students' cognitive abilities towards RME. The survey results were analyzed based on Bloom's cognitive ability level [2] (revised by Anderson & Krathwohl, 2001) and the PISA, OECD competency level. From the analysis that the researchers carried out on the second survey data given to students, they categorized student answers into groups of "understanding" and "not understanding" RME as shown in table 1.

Table 1. Frequency and percentage of student categories and sub-categories.

Categories		Sub-category	Frequency	%
Reproduction	Knowledge	Have knowledge about RME	32	64%
		Less or no proper knowledge about RME	18	36%
	Comprehension	Have a proper explanation and interpretation of RME	18	36%
		Less do not have a proper interpretation of RME	32	64%
Connection	Application	Can apply knowledge of RME	17	34%
		Unable to apply RME knowledge	33	66%
	Analysis	Able to analyze knowledge about RME	13	26%
		Less able to analyze knowledge about RME	37	74%
Reflection	Synthesis	Able to express contextual problems	12	24%
		Not yet able to express contextual problems	38	76%
	Evaluation	Make and provide an assessment of the RME learning design	4	8%
		Not yet able to make and provide an assessment of the RME learning design	46	92%

Source: Yilmaz, R (2020), based on Bloom's taxonomy and PISA competency levels.

In the *knowledge* category in table 1, quite a lot of students know the definition of RME itself. As many as 32 or 64% of students explained the essence of RME as contained in the following answers:

"RME is an approach to learning mathematics that emphasizes the relationship between the real (realistic) context and the lessons to be received. RME tries to construct learning from real contexts and then modelling both in the form of images and other forms into abstract mathematics."

However, there are still 18 or as many as 36% of students who cannot explain what RME is, as explained in the following answers:

"RME is an approach in learning mathematics that uses real objects, or concrete objects in learning."

This answer is not correct because it indicates RME must use real objects in learning, whereas according to Van den Heuvel-Panhuizen, M & Drijvers, P., "Although realistic situation in the meaning of real-world situation is important in RME, realistic has a broader connotation here" [16] (Van & Drijvers. 2020). This explains that the meaning of "real-world" does not only lead to real objects, but rather to real situations/contexts for students. Here are other answers that don't yet describe what RME is:

"RME is a model in learning mathematics that builds relationships through social interaction and also between one material and another."

This answer has not described the core of the RME itself which originated from human activity, so that the real context that should have emerged is not visible.

Furthermore, in the *comprehension* category, which emphasizes a more comprehensive explanation of the characters and principles of PMRI. There were 18 or 36% of students who were able to explain in more detail about RME. Here are the correct answers given:

"RME is an approach that reveals an experience and event that is close to students as a means to understand a problem in learning mathematics. The purpose of RME learning itself is to provide opportunities for students to experience mathematics directly and more actively."

"RME is oriented towards the use of real contexts. The use of models so that students can build their own knowledge (self-developed model). The teacher acts as a facilitator who presents these real problems."

In the two answers above, the characteristics and principles of RME have emerged, namely experiences and events that are close to students through guided reinvention so as to provide a more meaningful learning experience. As well as the use of their own models by students (self-developed models) is one of the keys to RME. Then there are 32 or 64% of students who have not been able to explain comprehensively about RME, the following is an example of the answers given:

"The RME learning framework provides a systematic description of the implementation of learning that emphasizes process skills, collaboration and argumentation."

In this answer the five RME characteristics and principles have not been described, so this answer is still very general which can be found in many learning approaches.

Next is the *application* category, where in this category questions, students are asked to explain how to apply RME in learning mathematics. There were 17 or 34% of students who were able to provide examples of RME applications. Here's an example of the correct answer:

"In its application, the teacher as a facilitator provides real (contextual) problems to students by connecting the material to be taught. Students as learning centres, grow knowledge independently through modelling and are active during the learning process."

"The application of RME begins with the use of contexts that are close to students. The teacher presents related material. Students reinvent concepts through problem solving. Teachers in motion learning are a little limited because students themselves build models so that the learning experience is more meaningful."

In both of these answers, the main characteristics of RME have emerged [19] (Zulkardi, 2002), namely the use of context as a starting point, as well as the principle of self-developed models where modelling is carried out independently by students to find solutions to problems. As many as 66% or 33 students who have not been able to explain how to apply RME in learning as contained in the following answers:

"The application of RME is in the area of flat shapes. The teacher gives examples of flat shapes from objects around students, then students look for other examples. The teacher guides students in finding long and broad meanings. Then the teacher gives a way to calculate the area of the flat shape."

The answer is not right because students get mathematical concepts based on the results of their active activities during the learning process, not given. This is in accordance with what was explained by Sembiring, R.K, Hadi, S & Dolk, M in, in his article further explaining the principle of guided reinvention, namely "Mathematics should therefore not be presented as ready-made". This was further explained because guided reinvention emphasizes the learning process of students who get active during learning [13] (Sembiring & Dolk, 2008).

Furthermore, for the *analysis* category, students are asked to explain the differences between RME and other learning approaches that have previously been studied. There were 26% or 13 students who were able to explain well the differences between RME and other learning approaches, as shown in the following answers:

"RME is different from PBL (Problem Based Learning), where RME uses contextual problems, close to students, while PBL problems do not have to be close to students' daily lives."

At the previous meeting, students had studied the PBL approach, and the main thing that differentiated it from RME was the context presented by the teacher as the first step in learning. Meanwhile, 74% or 37 students were unable to explain the differences between RME and other learning approaches. Here's an example of the answers given:

"The difference between RME and PBL is that RME has a relationship (linkage) between materials and builds its own model, whereas in PBL students do not use modelling to solve problems."

This answer is considered incorrect because modelling skills are needed in solving problems in PBL [14] (Silmina, 2019).

In the *synthesis* category, students are asked to design contextual problems that can be applied to RME. 24% or 12 students answered this question correctly. Here's an example of the answers given:

"Mother has 5/6 of the birthday cake then mother gives 1/2 of it to her daughter. How many cookies does mom have? The context is close to students and to teach the concept of fraction arithmetic operations. The presentation of these problems can be in the form of real objects/pictures or videos."

This answer is designed to teach the concept of fractional arithmetic operations in grade 4. As explained by Zulkardi, the RME context in this case is a real situation/experience for students. In the example problem designed by students, the context of the birthday cake is included in a personal context, so that it can enable students to be involved in that context.

However, there are 76% or 38 students who have not been able to design contextual problems that can be applied to RME correctly, as an example of the following answers:

"Students are given the opportunity to measure the length of time the top is spinning using a stopwatch, this is expected so that students are able to develop reasoning, for example, 1-2 minutes have passed when the top was spinning."

The problems described in this example do not yet show any relation to everyday life, so they still seem to be *forced* problems in order to bridge material about time.

In the last category, namely *evaluation*, students are asked to evaluate the context that has been designed if it is applied with a learning approach other than RME. There are 8% or 4 students who have been able to evaluate the problems they designed as in the following answers:

"The concept of fractional arithmetic operations is expected to be mastered by students with the RME approach which starts with contextual problems. However, if this concept is taught using PBL, it may not need to be in the form of word problems and the solution can be done using arithmetic techniques."

In this answer, for problems that have previously been designed, if you use RME with questions in the form of a story and the context of "birthday cake", then if taught using PBL, it may not be in the form of story problems and to solve problems, students can directly use modelling. Because in the RME step the concept of iceberg is known [1] (A Fauzan, 2018), at the beginning of learning students are provided with contextual problems that can be solved by themselves using informal knowledge (real objects, pictures or sketches). Then these problems facilitate students to use their own symbols or strategies. It is as if it is located at the bottom of the iceberg, with a strong foundation or portion. Then after that the teacher can facilitate so that later on the main goal students are able to do formal subtraction (using mathematical symbols). Then there are 92% or 46 students who have not been able to analyse contextual problems that they have or cannot design in the previous questions. This is possible for this to happen because at this level a deeper understanding of RME is needed as well as other approaches as a comparison.

CONCLUSION

Based on the results and discussion of the research, the implementation of cooperative learning during three meetings which taught theories in the RME approach, simulations of the RME approach and at the last meeting students designed learning using RME gave a pretty good picture of the results in understanding RME theories. These theories are in the form of RME principles and characteristics. This is as found in previous research [9] (Pramudiani et al, 2023), that it is quite easy for teachers and prospective teachers to understand RME theory, especially the use of context as a starting point for students to build knowledge of mathematics.

Meanwhile, there was a decrease in the frequency when students were asked to explain RME applications in learning mathematics and to analyse differences with other approaches. Students find it quite difficult to explain the RME application because RME itself is a learning approach that does not have predetermined learning steps like several approaches. It's just that in RME there are clear principles and characteristics that can be directly implemented in learning mathematics. This is supported by the results of previous research [3] (Agustiani, 2015), that for further understanding (analysis) it is good if teachers and prospective teachers often train/develop RME practical skills. So that the focus of achievement is not only on theoretical reasoning but also on skills.

In the reflection: synthesis and evaluation category, there are still a few students who are able to design contextual problems that can be implemented in RME. There are also many students who have not been able to provide an evaluation of the problems designed for approaches other than RME. Most students have finished designing problems but not including contextual problems. This is in line with research conducted by Sari & Noviartati, that students' understanding of "context" is limited to presenting context, namely in the form of problems [12] (Sari & Noviartati, 2022). Students have not been able to explain and design how situations can be selected into contexts that can help students rediscover mathematical concepts. Findings regarding students' difficulties in designing good contextual problems are also discussed further. These findings explain that teachers and prospective teachers do not know what their students think so that it is quite difficult to determine real contextual problems in everyday life. Another reason is also added, namely that teachers and prospective teachers still need to add more knowledge/mathematical concepts by practicing and studying independently. One solution that can be offered is reinforcing the relationship between teaching material and the problem in daily life [17] (Wahyudi, 2017) so that prospective elementary teacher can be more related during designing contextual problems related to the topic.

Of course, from the results of the description of the cognitive competence of fourth semester prospective elementary teachers towards RME with the application of cooperative learning, it is still very possible to continue to experience development. This is because there are still 4 more semesters to be taken and more opportunities to explore RME, both in theory and practice. It is hoped that this description can provide input for lecturers and university leaders as follow-up material so that the competence of graduates as prospective teachers can be fulfilled optimally.

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